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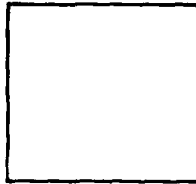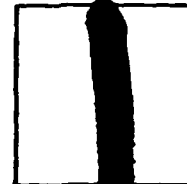
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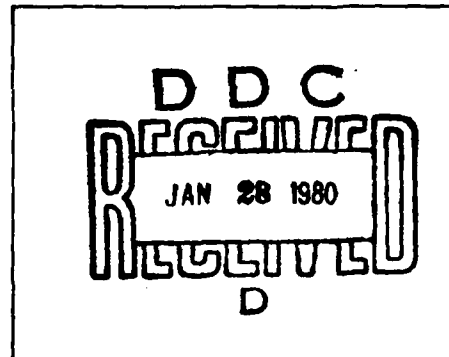
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"AIRCRAFT AND ASTRONAUTIC ENGINEERING"
(SELECTED ARTICLES)

EDITED TRANSLATION

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Table of Contents

Some Problems of the Canard Configuration   by Jan Staszek

CONCLUSION

The subject of the analysis is the effect of the anterior control of the canard type airplace on the aerodynamics of the wing, the problem of longitudinal and lateral stability, the effect of gusts on the loading magnitude and some practically observed phenomena connected with the dynamic stability of a plane with this type of arrangement.

Notes and remarks are limited to the discussion of several special features of the canard configuration flying at low speeds (Ma < 0. 5).

Some Test Results from an F19a Ente Flight

In flight testing of the F19a Ente airplane which was conducted in the '30's showed several peculiarities of the canard arrangement.   The qualities revealed have a positive as well as a negative character and are deserving of more individual theoretical analysis and experimental verification of the results.   Without going into the particulars of the experiments conducted on the F19a Ente (1), (2), the following findings can be extracted from them:

--small interferences in the fixed state of flight lead to unsuppressed longitudinal oscillations, at higher speeds, as indicated by the curves in Fig. 13, the violent displacement of the elevator (pulling) 0. 4.° lead to longitudinal

oscillation in this plane having an amplitude of about 10° at a 12 s. frequency. These oscillations were not suppressed although they did not display the tendency to increase. The amplitude of altitude changes amounted to about 15 m. (c-a 1.3 mm of Hg pole), the difference in dynamic pressure, however, during this equalled about 20 mm. of H_2O pole (oscillations from dynamic pressure of 30 mm. H_2O to 50 mm. H_2O, which corresponds to the oscillations in velocity from 22 m /s to 28.3 m /s). The results of the measurements of this case are shown in Fig. 13;

-- the violent, great displacements of the elevator lead to the rise of suppressed longitudinal oscillations, during which the suppression increased during greater displacement. During violent elevator displacement of 4.7^o the longitudinal oscillations decreased from an amplitude of 15° to 3° after four periods and about 52 s., while during elevator displacement of 9.8^o longitudinal oscillations were suppressed from the first equalling 12° after four periods and about 45 seconds. During this, the decrease in initial flight altitude was not proved, however the fact that the airplane did not pass to climb flight after oscillation suppression can be explained either by the increase in drag during greater, about 8°, angle of attack, or by the impossibility of achieving a larger factor of aerodynamic lift on the wing. The curves in Fig. 14 show the nature of the changes;

2.

-- slow displacement (pulling) of the elevator up to the maximum 18.5^O did not produce any oscillations, but only a gradual passage to a new angle of attack, larger than the starting one at about 9.5^O, during which the plane was stable in this whole range of angles. Curves in Fig. 15 characterize the results;

-- the violent elevator displacement while sumultaneously turning on full gas allowed passage to a new stage of flight after just one oscillation during which the gain in elevation averaged about 37.5 m., and the change in angle of attack was about $+6^O$. Unfortunately there is no data on the displacement angle of the control, which would have permitted a comparison with the phenomena which Fig. 14 characterizes; the nature of the changes is shown in Fig. 16. They indicate that the addition of the gas had the effect of clearly suppressing the oscillation and that this type of maneuver was not dangerous when connected with an increase in altitude. This is particularly important during low flying in connection with the necessity of jumping over ground obstacles;

-- together with an increase in velocity (dynamic pressure) there was observed a decrease in the suppression of longitudinal oscillations, which is connected with a decrease both of static and dynamic stability, at small angles of attack. At a dynamic pressure of about 40 mm H_2O (which corres-

ponds to a velocity of 90 km /h) suppression declined and the craft became

dynamically neutral with a blocked elevator. Suppression increased together

with a decrease in velocity and passing to greater angles of attack and larger

difference in the values of the coefficients of aerodynamic lift of the control

surfaces and wing. Dynamic stability also increased and the duration of one

oscillation decreased during this from 14 s. when q = 45 to 11 s. when q = 33.

The nature of the changes is shown in Fig. 17;
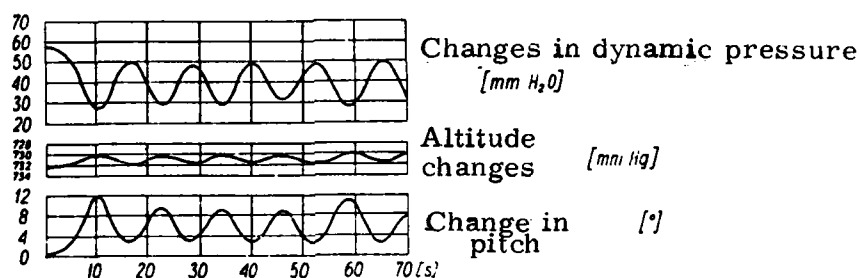
Fig. 13. Behavior of F19a Ente after violent displacement of elevator of 0. 4° (1).
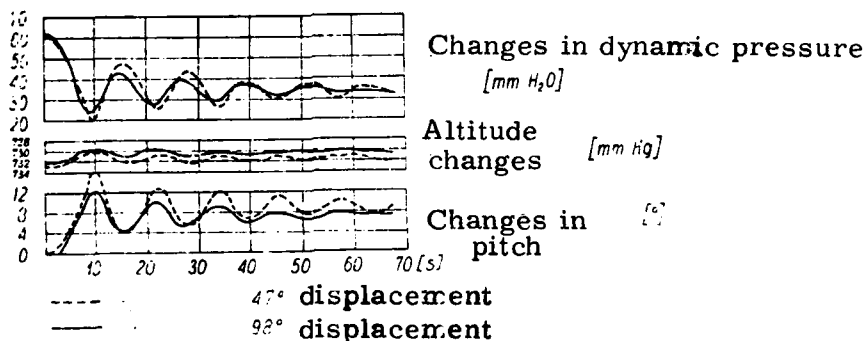
Fig. 14. Behavior of FW 19a Ente after violent elevator displacements (1).

4.

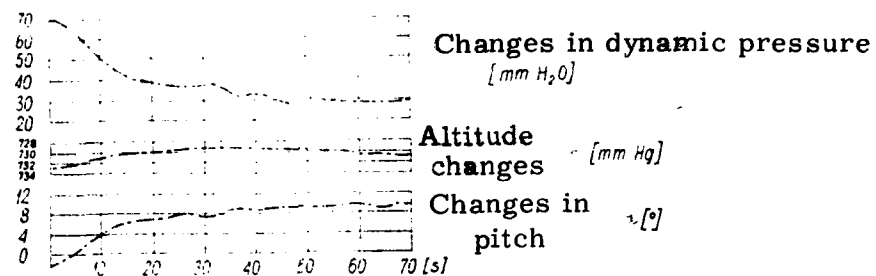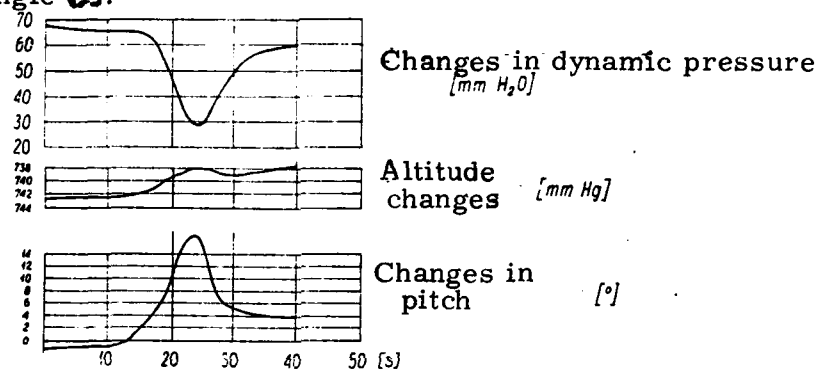Fig. 15. Behavior of FW 19a Ente during slow elevator displacement at 18.5° angle [1].

Fig. 16. Behavior of FW 19a Ente during violent elevator displacement with sumultaneous addition of full gas [1].

Time of one oscillation [s.]

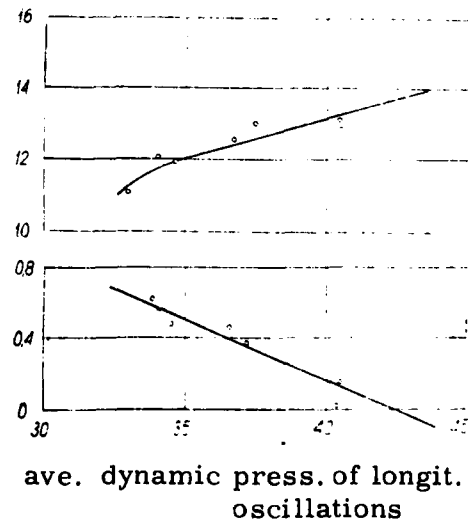Logar. coefficient of decreased suppression

ave. dynamic press. of longit. oscillations

Fig. 17. Suppression of longitudinal oscillations of FW 19a Ente [1].

5.

-- the somewhat successfully chosen shape of elevator unit (a severely tapered trapezoid with a straight edge of attack on the whole span) caused an irregular flow around a body. Visualization of the flow was realized by using wool threads fastened to the wheels proturding from the control surfaces. It revealed that a big difference in angles of attack of the wing and elevator unit, amounting to 10° deepened the difficulties in achieving a regular flow around a body when there are larger angles of attack in the wing, since the control surfaces had a large angle of attack even during maximum velocity. At a velocity under 100 km /h. only the tips of the control surfaces had regular flow around where the situation was saved by the slot of the control surface when there is a great relationship of elevator unit depth to the depth of the stabilizer. This fact of irregular flow around a body on a large part of control surfaces lessens the significance of measurements obtained and does not allow a full analogy to other, more regular aerodynamic solutions;

-- the results given above suggest certain directions for overcoming the problems of stabilization and control in the canard configuration, however more precise numerical data concerning the F19a Ente plane itself is lacking, its polar curve and those determining the factors of stability and maneuverability do not permit a more concrete opinion or conclusions. There is no way to evaluate if the test results of suppressed and not suppressed oscilla-

6.

tions are an individual quality in construction or if they can be expanded into a canard configuration at all; neither are there any numerical data concerning the speed of control displacement and in connection with this, it is not known which displacements should be considered slow and which violent;

-- the remaining test results do not present very interesting material. They underscore only the necessity of continual development of the craft from an aerodynamic point of view for the purpose of · taining better performance; neither does it have any data pertaining to lateral stability, but directional stability was achieved by using a very large vertical tail unit necessary with regard to its small distance from the center of gravity.

Lateral Stability

The effect of distortion of the main wing flow around of a body caused by streams and vortices flowing off from the control surface is clearly useless in the case of lateral stability in a canard arrangement. This effect reveals itself particularly negatively during a non-symmetrical flow, e. g. , in a slide or also during take-off with cross-wind, or with lateral gusts. The wing on the windward side has a more advantageous flow around (larger C_z) when the wing on the lee side has a flow around less advantageous (smaller C_z) as a result of greater distortion of flow through streams flowing from the elevator unit, as Fig. 18 indicates. There then occurs a moment around the longitudinal

7.

axis turning the airplane in the directio.. of the wing with the smaller coeffi-
cient of aerodynamic lift, and thus to the lee side. The canard thus has the
same tendency as a conventional airplane with a large wing lift, namely, the
lateral gust tilts it near the longitudinal axis in an unfavorable direction which
causes the wing to roll up on the "windward side." This phenomenon can be
dangerous during stronger lateral gusts at low altitude or at take-off for
pilots who are accustomed to standard wing-control surface arrangements.
This phenomenon can be counteracted by using a negative wing lift.

There is no doubt either that with a carnard configuration slides are
different than with a standard plane arrangement, and so in the training for
piloting a canard type plane the pilot should develop other habits. Displace-
ment of the rudder always causes tilting the canard in the opposite direction
than that expected of the craft, and thus entry into a slide. For this reason
also the aileron reaction must be more energetic than in a standard arrange-
ment. In effecting a turn, consequently, the airplane tilt advance should be
used in the direction of the turn in relation to the displacement of the rudder.

The conventional arrangement is rather less susceptible to these
phenomena since the whole control surface is almost always found in the area
of streams flowing from the wing and the asymmetry of flow does not play a
larger role in the event of a small wing lift or the absence of it, affecting
only change of flight direction.

8.

Conventional   Canard
configuration   configuration
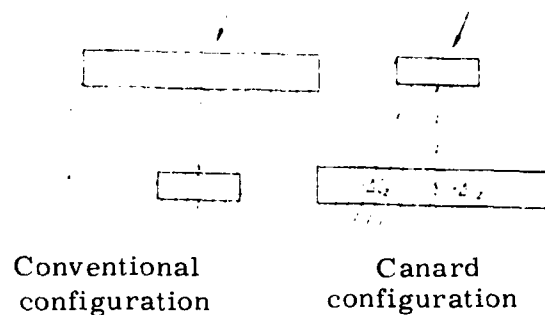
Fig. 18. Effect of oblique flow.

To the difficulties connected with lateral stability we can add also the small directional stability of this configuration due to the large lateral surface of the fuselage located in front of the center of gravity. This   is a result of the necessity to situate the elevator unit on a suitably long arm to obtain longitudinal stability. Moreover, the location itself of the elevator from the front has a definitely unfavorable effect on the directional stability, opposite than in a conventional arrangement. This unfavorable effect reveals itself above all, in large angles of attack.

To counteract these phenomena of course it is possible to enlarge conspicuously the surface of the vertical tail unit, however it turns out to be abnormally large considering its small distance from the center of gravity. This small arm also causes small suppression of directional oscillations and, practically speaking, it is very difficult to build a canard having the directional stability that a plane has with a conventional configuration. A large vertical
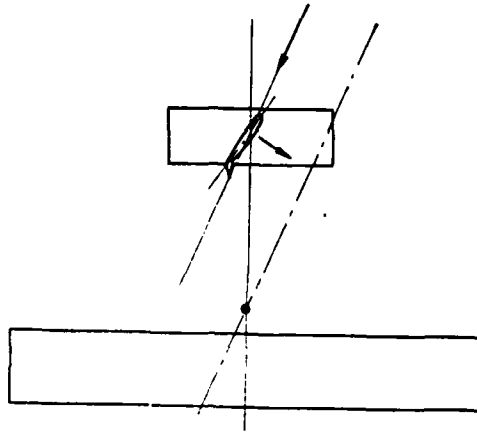
Fig. 19. Floating fin.

tail unit greatly complicates the construction and enlarges the drag of a

standard sized control, thus it would have to be moved in a suitable outrigger

to the rear which complicates even more an already non-typical construction.

In order to avoid giving large surfaces for a vertical tail unit because

of its small distance from the center of gravity, R. Lopez [3] suggests placing

the floating vertical fin at the front in the area of the elevator unit.   This

stabilizer provided with a control flap displaced in a direction opposite to the

displacement of the stabilizer itself gives a moment opposite to the plane's

yaw (Fig. 19).

Flap displacement is connected kinematically with the displacement of

the stabilizer and acts on the principle similar to that of a trimming tab.   A

disadvantage of this solution is that the effect of friction cannot be removed and the difficulty of eliminating slack and elasticity of joints, which decreases the operational efficiency of the equipment at small angles of deflection from the direction.

Stall

Another specific phenomenon enters into the abnormal behavior of the canard configuration. With too large a surface and span of the anterior elevator unit in large angles of attack, a violent transition into a deep dive can occur. For, if flow separation on the control surface with a large angle of attack takes place and violent fall of its aerodynamic lift occurs, then simultaneously jet deflection toward the bottom decreases and the main wing on which the separation did not yet take place will be washed under a larger angle of attack. Both a decrease in the aerodynamic life of the control surface and an increase of it on the wing give in total a great negative moment causing the plane's transition into a dive up to the moment of acceleration and recovery of aerodynamic lift in the elevator unit. The phenomenon takes place during violent loss of elevation and for that reason in certain flight conditions can be dangerous. This is especially unfavorable when aerodynamic hysteresis of the control profile exists, which delays recovery of aerodynamic lift on it. Thus in certain cases the mushing of the canard in large angles of attack can end with a transition into a dive. This phenomenon

11.

occurred in the H. Mignet plane Pou du Ciel with a tandem configuration even at take-off during stall at full engine power.

This phenomenon can be counteracted by selecting the proper ratio of surface and span of the elevator unit and the main wing and using for the elevator unit profiles having a large maximum coefficient of aerodynamic lift and very flat polar curve or providing control surface in hyperlift equipment. This last, very effective solution, also improves other features of the canard configuration.

Effect of Vertical Gusts on Loading

Tests on the influence of vertical gusts (flight in turbulent atmosphere) on the increase in surface loading conducted at the Langley Field laboratory [6] indicated that in the case of the canard configuration this influence is greater than for a conventional configuration. Indeed, with a standard arrangement the zone of the gust includes from the first the whole surface loading and it could be expected that aerodynamic impact will be more "hard" causing greater accelerations, but in the case of the canard configuration the elevator unit being the first to enter the zone of gust, before the main wing, causes the rise of the moment around the lateral axis passing through the center of gravity of the plane and pitching of the plane around this axis. The wing, thus, enters the zone of vertical jet already under a somewhat changed, larger angle of attack

12.
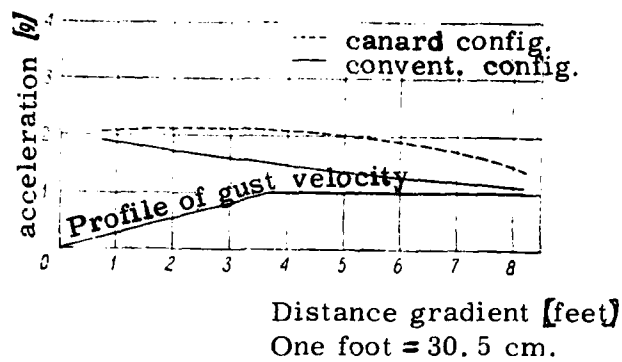
Fig. 20. Effect of vertical gust on increased load.

and the action of the gust is more energetic.

Tunnel tests were performed with three different profiles of vertical speed of gust, changing from zero to maximum value at intervals of 0.7; 3.7 and 8.2 feet (210 mm; 1,125 mm and 2,500 mm). The tested model had the following measurements:

control surface span   365 mm

wing span   940 m m

distance of center of aerodynamic wing from
center of aerodynamic control surface   356 mm.

The tests were performed at an average gradient of vertical speed (change from 0 to V_{max} in a space of 1,125 mm) and made it possible to establish that the maximum of acceleration does not happen at all when both lift surfaces are entirely in a homogeneous stream, but occurs somewhat

13.

earlier. Loading increases in the elevator unit during this reach values greater than in the main wing.

In comparison with the conventional airplane loading differences exceed 25% to the detriment of the canard. The graph in Fig. 20 presents comparative results of tests of a concrete case of a standard Boeing B-247 airplane with the canard type configuration defined above.

Airports in the Contemporary World*   by Jan Smolenski, M. Eng.

The article presents the airport as a factor in site planning.   The location

requirements of an airport are given.

Part 3

The Airport as a Site Planning Factor

Airport Location Requirements

The costs connected with building airports are certainly not trifling

but they are not as great as they could appear to be on the surface.   The fol-

lowing sample calculations illustrate this.

With an expenditure cost of about 1 mld. F ($200 million -USA) a

large international airport can be built completely equipped, capable of being

developed to serve 10 million passengers annually.   Granting a yearly amorti-

zation even of 10% in calculating per passenger this cost amounts to 10 F.

Then taking into account that the average world flight distance is within limits

of 1,000 km. and each airline is served by two ports the construction cost of

such a port in relation to one pass./km   can be determined as 2 French cent-

imes. In comparison the construction cost of a track for high speed trains is

*Acc. to Jacques V. Block: Les Aeroports et l'environnement (Airports

and Their Environment) pub. Aeroport de Paris--May, 1971.

15.

within a range of 4 mln. F/km. With a 5% amortization this amounts to 200,000 F/km annually, thus to reach a cost per unit to the order of 2 centimes per pass./km it would be necessary for such a track to transport 10 million passengers annually. There are few track connections in the world which have such great traffic.

Moreover an airport once built has the potential to unite the region it serves with the entire world while a railroad track can unite only those points located on its route.

This simplified reasoning probably fulfills its purpose and namely, underscores the fact that the construction cost of airports cannot be a barrier for the development of air transportation, particularly in comparison with the infraconstruction costs of other types of transportation. However, serious difficulties can sometimes occur in the area of the location of the airport when there is concrete agglomeration since this poses rigid location requirements. First is the matter of the size of the area. The surface area needed to install the equipment to accept annually 1 million passengers or 100,000 tons of freight is determined at about 100 ha.

For example: Orly airport covers 1,500 ha , and Roissy-en-France (now the Charles de Gaulle airport) 3,000 ha , which is 1/3 of the Paris area (without the suburbs). These surface areas result from the necessary runway
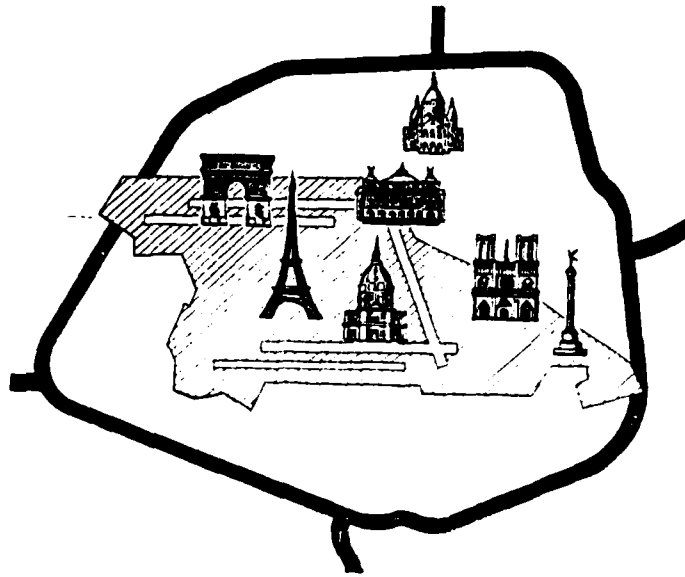
1.   Surface of Roissy-en-France airport in relation to surface area of
Paris bounded by exterior boulevard.

lengths, from the area of air strips and approach areas, as well as from the

network of taxiways, which is continually being expanded for large airplanes

and for runway needs of quick deceleration.   Next, land measurements are

determined by the necessary surface area for passenger terminals, stores,

hangars and shops, demurrages for the planes, vehicles, parking areas, and

all other facilities necessary in an airport.   It is obvious that finding land

measuring several hundred or several thousand ha. in urban areas is becoming

more and more difficult.

The size of the site for airport needs is only a part of the problem. The safety of the air carriers requires restrictions in the area of natural and artificial obstacles around the airport, particularly sharp objects on the landing approaches. For this reason also sites which have a varied relief and are strongly built up are of little use. It is also necessary to consider the safety of radio or radar equipment against interferences resulting from ground conditions which, in certain instances, can cause great difficulties.

Moreover, an airplane is rather sensitive to cross winds and visibility conditions, particularly during landing. Despite the technological progress in electronics and automation, even with the positive results already obtained in dissipating fog, sites which are quite foggy should definitely be avoided.

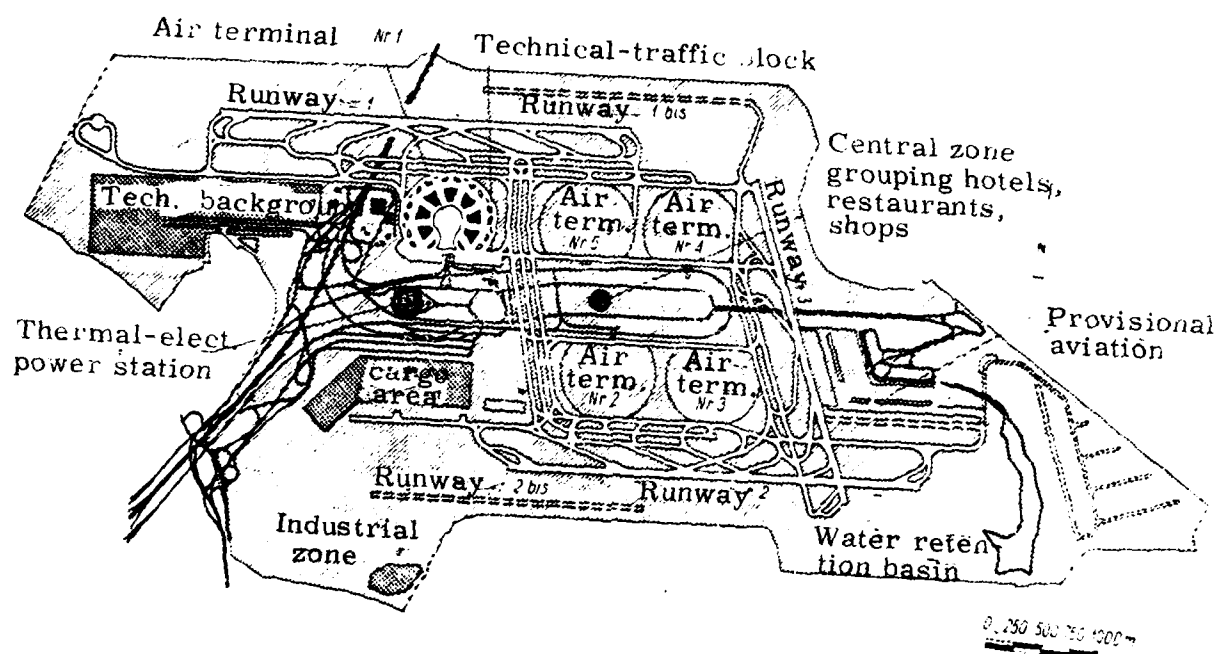Runways should be situated in compatibility with the generally prevalent wind directions, although currently there is no need to construct several crossing runways so that take-offs and landings could take place always with the wind.

These requirements are not yet final for even an excellent location on the ground can seem useless insofar as the corresponding free airspace does not accompany it.

For each runway it is necessary to have free airspaces for landing approach, for take-off climb and in the waiting zone, during confirmation of proper separation between planes. These spaces are large and have the tendency to increase together with an increase in the speed of contemporary planes whose radius of turn in flight amounts to several kilometers. Moreover there exists here the problem of collision of air zones of various civil and air force airports. These collisions occur more and more often in regions which are heavily urbanized having a thick network of airports, which leads to the need to use joint air traffic control.

In view of the construction cost of an airport sites should be avoided which are very expensive, excluding, e. g. , mountainous areas. Also to be avoided are sites where it would be complicated to situate buildings, sewers for drainage and water, water and energy consumption would be complex or difficulties arise in the area of construction materials.

An unusually essential problem is air noise which became the number one obstacle in the localization of airports. This problem will be discussed in a a more detailed way in the following article, nevertheless it should be pointed out now that of all the difficulties connected with air port location the matter of noise is the severest. This matter evokes rage and is often handled in a demagogical way as a center of pressure, without allowing rational, objective analysis.

19.

Air terminal Nr 1

Technical-traffic block

Runway 1

Runway 1 bis

Central zone grouping hotels, restaurants, shops

Tech. background

Air term. Nr 5

Air term. Nr 4

Runway 3

Thermal-elect power station

Air term. Nr 2

Air term. Nr 3

Provisional aviation

cargo area

Runway 2 bis

Runway 2

Industrial zone

Water retention basin

0 250 500 750 1000 m

2. Conceptual design of 3-dimensional development plan.

20

It seems necessary that the air noise problem be explained and clarified, because it is necessary to struggle both with the unfounded, often exaggerated fear of noise and the desire to erect dwellings in zones stricken with really annoying noise.

Hence it can be concluded that airports should be located at a distance from urbanized zones where there is no lack of space on the ground and in the air. However, considering the necessity of transporting passengers and freight as conveniently, quickly and economically as possible, an excessive distance of air ports from the centers served by them is not acceptable. Remoteness of an airport is, above all, contradictory with the essence of air transportation, whose dominating quality is speed. For this reason time gained with quick airplane cross-country flights can not be lost on trips to and from the airport. This problem within the scope of increase in airplane speed appears more and more strongly in close and average air routes and in time implementation of supersonic planes into regular communication will apply also in instances of long-distance airplane flights.

In connection with searches for an ideal facility, the outlook came that there is nothing left to do but to connect airports with the centers they serve by quick on-ground communications facilities. Unfortunately in this area there are numerous obstacles which are difficult to overcome.

First: such a facility should be very quick, theoretically as quick as
the airplane, which at the current state of technology is practically unattain-
able, and at any rate costly, particularly in heavily urbanized areas.

Second: to avoid losing time waiting--the on-ground transportation
facility should course very often, which considerably increases service costs.

Third: implementing an intermediate transport facility causes a
breakdown in transportation, additional losses of time and creates new com-
plications rather than improving service, whereas it is possible to get to a
closely situated airport directly by automobile.

Fourth: a remote airport leads to the concentration of the entire on-
ground traffic in one artery uniting it with the urbanized zone, and with that,
the artery in its entire length must anticipate traffic at peak hours. On the
other hand when the airport is situated closeby, accesses can be divided into
many arteries, which can profit other users as well. All these difficulties
lead to the proven fact that the remoteness of an airport from centers is tied
up with considerable costs. For example, a complex study has been elabora-
ted on the eventual localization of a third large airport near Paris, whose
realization would take place near 1985. In the case of the airport situated
75 km from Paris the costs connected with the transportation of 30 million
passengers to a new port is estimated at 2 mld. F annually ($400 million, USA),

22.

more than the transfer of these same passengers to Orly and de Gaulle air-
ports, situated 15 and 25 km from the center.

This comparison confirms that it is more profitable to integrate air-
ports with an urban agglomeration than to remove them from the center of
the city. The location of an airport should be as close to the urban zone
which it serves as is possible, naturally with a simultaneous tie with the
entirety of the communications system of a given agglomeration. Moreover,
an airport requires proximity of the city by right of the employment it offers,
which is not minimal.

Consequently, the test of separating an airport from the city can bring
about either the "natural death" of the port, if there is no sense to its exist-
ence, or will lead to the emergence of a new city around this port.

It must also be noted that an airport can affect the surrounding envir-
onment, plant and animal, both during the building stage and in the service
process.

Airport construction can often be connected with the liquidation of
considerable cultivable areas, can influence the change of hydrogeological
relations, and consequently disturb the balance of nature, which can be partic-

23.

— super-highways, existing or under construction
☐ urbanized zone
■■■ anticipated super-highways
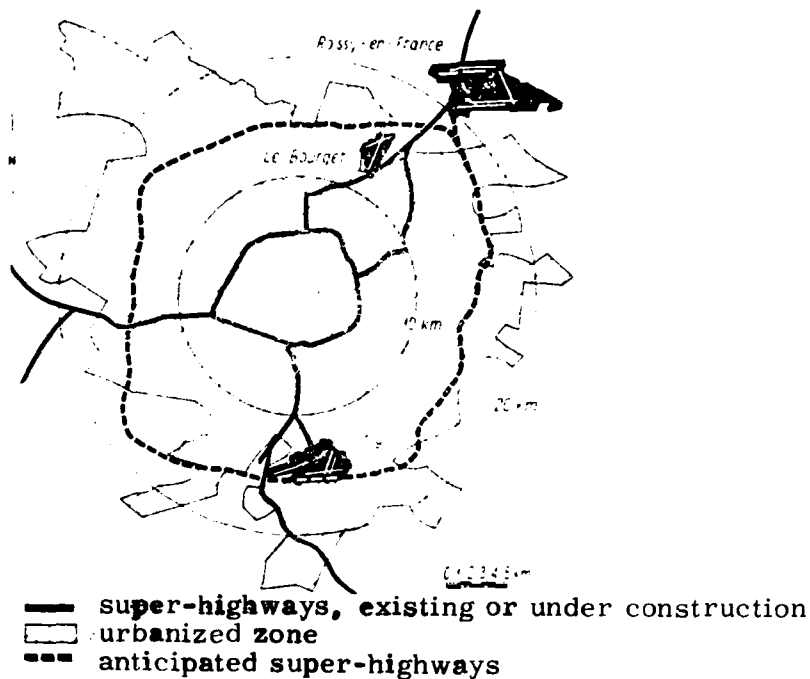
3. Paris area.

ularly essential in the case of building in established zones, e. g. , natural

reserves of the plant or animal world.

The natural and agricultural consequences are easy enough to evaluate,

but a disturbed balance can be overturned by proper technical advances, both

in the scope of hydrogeology and land covering. On the other hand the conse-

quences of the effect on animal life are more difficult to evaluate and piece

together. In reviewing the airport service problems in connection with the

plant and animal environment it is necessary to take into account the possibi-

lity of a two-sided reaction. On one side the effect of airport exploitation can

24.

be the discouragement and even destruction of certain types of plants and animals. On the other side the existence of some animals near the airport can be a threat to flight safety (birds).

For this reason in selecting an airport location it is necessary to avoid sites of bird migrations as well as areas which can be food sources for them (garbage disposals, soaked ground, water areas).

The given requirements concerning airport localization indicate that existing ports of their own right are a valuable asset and consequently should be protected and maintained, even if their usefulness at the present time is not completely justified. It should be anticipated that in the future when these needs become actual the finding of another location can be very difficult. Unfortunately this is not always understood by some community authorities who see in airports only flat land easy to be developed and are often ready to bury matters of the future for temporary effects.

Here it must be added that reserving sites for future airports should be done with great forethought, and in the plans for developing three-dimensional transportation of the whole infrastructure, airport problems should have priority, since their actual location is a particularly complicated matter.

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